ТЕОРЕТИЧЕСКИЕ И ЭМПИРИЧЕСКИЕ ИССЛЕДОВАНИЯ

NONMARKETABLE ASSETS VERSION OF THE CAPM: THE CASE OF THE RUSSIAN STOCK MARKET

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The paper deals with a modification of the CAPM, being called the Mayers model, which takes into account the existence of nonmarketable assets. Human capital is the classic example of such assets though we present and discuss some other important examples. This approach, as well as more advanced conditional CAPM, gives a correction to traditional CAPM beta coefficient as a measure of market risk. In this paper we present two attempts to test CAPM with nonmarketable assets. First, we start from analysis of the small size effect of the Russian stock market. We show that in this case the Mayers model gives the possibility of substantial improvement of risk exposure estimate. Second, empirical analysis in the case of human capital shows no impact of the Mayers model in all sectors of the Moscow Stock Exchange other than Innovation.

Keywords: nonmarketable assets, CAPM, the Mayers model, Russian stock market, human capital.

JEL: G11, G12, G32, J24.

Capital Asset Pricing Model (CAPM) is central for the discipline of corporate finance. During her more than half-of-the-century history it has been many times criticizing, rejecting, modifying and reviving. Modern standing of CAPM, of course, shows tremendous qualitative transformations. In recent survey [Bukhvalov, 2016] the author characterized the current status of the model as the foundation of *the modern managerial theory of the firm*. CAPM has transformed from the tool aimed for asset traders to really universal model. Now it is reflecting and guiding every firm's managers' efforts

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through the modified concept of systematic risk (cf. [Babenko, Boguth, Tserlukevich, 2016]). On the other hand, new model is consistent with modern empirical trends in asset pricing and trading.

In this paper we will return back to the early days of CAPM's modification, i.e., to the CAPM with *nonmarketable assets*. This model appeared in the beginning of 1970s in the stream of M. Jensen's research, which treated CAPM as a particular case of general equilibrium model [Jensen, 1972]. It was invented by David Mayers, his student (see [Mayers, 1972; 1973]).

CAPM with nonmarketable assets allows assets owned by investors who obtain uncertain income from this ownership but public trades in such assets is impossible due to institutional or technological issues. Mayers himself saw the main interpretation of such assets as a form of human capital.[1] For that reason he used sub/superscipt H for them.

Classical CAPM and the Mayers model as its extension until very recently were the only theoretical models in asset pricing theory, which had solid economic foundation in the equilibrium theory. Multifactor asset pricing models that followed the appearance of the Fama–French three-factor model had applied econometrics origins. They obviously were better fit into reality but three factors in few years became four- and then five-factor models. Further it became clear that, for example, any factor related to asymmetry of returns can be associated with econometrically sound risk premium, i.e., a new factor. Fortunately, from the beginning of 2000s the approach from corporate finance and real options theory (with its stochastic differential equations techniques) has shown another perspective. Many new great names have appeared. The story of these contributions was presented in some detail in [Bukhvalov, 2016]. This modern theory is still in the shape of development. So, for some principle issues we still need to return back to not very technical versions of classical CAPM and its modifications. It is even more reasonable because new theorists still keep the place for application of CAPM for WACC evaluation and, hence, for investment projects appraisal (see [Bukhvalov, 2016, Section 5]). That's why we devoted this paper to the Mayers model.

The notion of nonmarketable asset should not been treated literally. Any nonmarketable asset can be "a little bit" traded. It means that in a certain sense it can be sold and bought with higher transaction costs, or unusual efforts are needed to maintain trade, or its liquidity is very low and price is uncertain, or institutional barriers for trade exist (but still workaround in possible), and so on. This issue was discussed for the case of human capital as early as [Fama, Schwert, 1977] paper has appeared. It is very difficult to model such "a little bit" feature. This notice was a starting for [Bukhvalov, 2008] where the Mayers model was expanded to include new areas of applications.

Main contributions of [Bukhvalov, 2008] are the following. First of all, a new managerial model of the firm was invented. It was assumed that the firm has two types of investors: most interested investors (key owners, top managers, activist members of the corporate board) and outsiders (all other shareholders and speculators). This is an institutional and rather stable division. Its importance is explained by institutional asymmetry, which is caused by ability for the most interested investors to implement their strategic decisions, rather than informational asymmetry, which is also present. Modern strategic management states that each company lives in uncertain and unpredictable business environment and real options are the main tool of creating company's value [Grant, 2016, Ch. 2]. Real options are designed and exercised (or not) by the most interested investors. So it is reasonable to treat real options as strategically important nonmarketable asset. Now two values for two above mentioned classes of investors should be assigned to the com-

[1] Of course, there are numerous studies on human capital impact but they are not about the risk (betas). We will not consider such researches here.

pany. Outsiders get capitalization and usual CAPM beta whereas most interested investors get *strategic value* of the company (to be defined) and the Mayers beta as a measure of risk. More detailed presentation and other applications (e. g., corporate governance) are given in [Bukhvalov, 2008].

It was also suggested that empirical identification of such model can be done by means of analyzing M&A deals where strategic value appears (in the form of goodwill). The techniques from [Fama, Schwert, 1977] reviewed below here seems to be appropriate in doing so using M&A activities indices. It is possible to do it only for the markets with a good disclosure practices like the USA. Nevertheless, all time series machinery should be checked carefully for the relevant data. What is the source of a hope that techniques that has shown no impact for human capital will work with M&A. Such a hope exists because of high share of M&A market in the stock market.

The second contribution is related with the size effect, which exists in the Mayers model. Its importance was, as far as we know, noticed in [Bukhvalov, 2008] for the first time. Namely we speak about the ratio of nonmarketable assets to marketable ones. Human capital, being measured as wages and salaries, is much less than the stock market in the USA. So, the direct use of the static Mayers model has not shown any impact. But sometimes nonmarketable assets are much bigger than marketable ones. It happens with derivative securities where (broadly treated) open interest is much greater than the market of underlying assets and (if we will take into account swaps and other advanced derivative instruments) it is much greater than all spot markets together. Using this idea and basic formulas of the Mayers model (see Section 1 below) an explanations of world financial crisis of 2007–2009 was provided.

The original contribution of this paper is the following. First, we exploit the idea of the size effect to show that the Mayers model provides a significant correction to the market risk of the Russian companies. This is related to the small size of Russian stock market and sanctions, which affect the activities of Russian investors.

Second, significant difference between traditional CAPM beta and the Mayers beta for the Russian stock market has led to idea of analyzing for the same market the old problem of human capital impact on market risks. As in [Fama, Schwert, 1977] for US we found impact of human capital not being significant for entire Russian market and most sectors but for some sectors, primarily for Innovations, we observed its influence. A simplified version of [Fama, Schwert, 1977] techniques was used.

The structure of the paper is as follows. Section 1 provides a brief introduction to the Mayers model and a review of [Fama, Schwert, 1977] techniques of empirical testing. Section 2 is devoted to new applications of the Mayers model to the Russian stock market. Section 3 deals with the problem of human capital impact.

1. CAPM WITH NONMARKETABLE ASSETS

1.1. Brief overview

The Mayers model, or Mayers CAPM, was invented in [Mayers, 1972; 1973] (see [Goldenberg, Chiang, 1983] for further development). In [Copeland, Weston, Shastri, 2005, p. 162] a reader can find basic features and peculiarities of the Mayers model (unfortunately without derivation). In Russian the Mayers model (including its construction, main properties, and generalization) is given in [Bukhvalov, 2008, p. 25–31].

Mayers model is one-period model with usual assumptions from mean-variance analysis [Copeland, Weston, Shastri, 2005, Ch. 5–6]. To formulate main equations related to the model we use the following notation:

R_j — return of the firm j;

D_H — stochastic cash flow paid to all investors at the end of the period on nonmarketable asset;

R_m — return of the market portfolio;
σ_m — risk of the market portfolio;
V_m — total market capitalization;
R_f — risk free rate.

Equations for expected return $E(R_j)$ and market value of unit risk λ are provided below

$$E(R_j) = R_f + \lambda\left[V_m \operatorname{cov}(R_j, R_m) + \operatorname{cov}(R_j, D_H)\right];$$

$$\lambda = \frac{E(R_m) - R_f}{V_m \sigma_m^2 + \operatorname{cov}(R_m, D_H)}.$$

Let us rewrite the Mayers model in full analogy with CAPM introducing β^* coefficient as a new measure of risk, the Mayers beta:

$$\beta_j^* = \frac{V_m \operatorname{cov}(R_j, R_m) + \operatorname{cov}(R_j, D_H)}{V_m \sigma_m^2 + \operatorname{cov}(R_m, D_H)}.$$

Using simple algebra we can derive a relation between β_j^* and β_j:

$$\beta_j^* = \beta_j \frac{\left[1 + \dfrac{\operatorname{cov}(R_j, D_H)}{V_m \operatorname{cov}(R_j, R_m)}\right]}{\left[1 + \dfrac{\operatorname{cov}(R_m, D_H)}{V_m \sigma_m^2}\right]}. \tag{1}$$

Let us assume that total value of nonmarketable assets is equal to V_H and R_H is return on these assets. Then cov = (R_m, D_H) = $= V_H \operatorname{cov}(R_m, R_H)$ and, hence, we can rewrite (1) as

$$\beta_j^* = \beta_j \frac{\left[1 + \dfrac{V_H}{V_m} \dfrac{\operatorname{cov}(R_j, R_H)}{\operatorname{cov}(R_j, R_m)}\right]}{\left[1 + \dfrac{V_H}{V_m} \dfrac{\operatorname{cov}(R_m, R_H)}{\sigma_m^2}\right]} = \beta_j \frac{\left[\dfrac{V_m}{V_H} + \dfrac{\operatorname{cov}(R_j, R_H)}{\operatorname{cov}(R_j, R_m)}\right]}{\left[\dfrac{V_m}{V_H} + \dfrac{\operatorname{cov}(R_m, R_H)}{\sigma_m^2}\right]}. \tag{1'}$$

If V_m is much less than V_H then we can assume that their ratio is equal to 0. Using the formula for the traditional beta we get that for any company

$$\beta_j^* = \frac{\operatorname{cov}(R_j, R_H)}{\operatorname{cov}(R_m, R_H)}. \tag{2}$$

Formula (2) presents the size effect in this case (see [Bukhvalov, 2008, p. 28, proposition (B)]).

1.2. Empirical tests of CAPM with nonmarketable assets

Thus far only the version with human capital was empirically tested. The first paper on this topic [Fama, Schwert, 1977] made two important contributions. First of all econometric techniques has been developed. We will provide below all necessary details because it is either used directly in our study or important for comparison. Second, the conclusion of the paper is negative for the perspectives of the model. Namely, the difference between traditional and Mayers betas was proved to be negligible for US market (even after adding to the stock market that of government bonds of any maturity to represent more completely the whole financial market). This was a shock, and further development of studies devoted to influence of human capital on CAPM has been suspended for almost two decades.

In the middle of 1990s a dynamic version of CAPM, named conditional CAPM, was introduced, to a large extent, for capturing influence of human capital on the market risk. In [Jagannathan, Wang, 1996], as opposed to [Fama, Schwert, 1977], the confirmation of importance of human capital for US market has been empirically validated. Though the techniques do not rely on the Mayers model but the authors give credit to Mayers' contribution to the problem.

In [Jagannathan, Wang, 1996] authors considered the return on human capital in the context of the return on aggregate wealth. Following Mayers' assumption that human capital contributes a significant portion of the total capital in the economy the authors also made a notice that in the structure of total monthly per capita personal income in the US during the period of 1959–1992 the share of dividend income was less than 3%, while at the same time the share of wages and salaries was more than 60%. Growth rate of the per capita payoff to human capital in the economy was taken as a proxy for return on human capital, similar to the measure suggested by [Fama, Schwert, 1977] research. Even though [Jagannathan, Wang, 1996] arrive at this measure being based on different lines of reasoning, the calculation is the same as in formula (3) below.

In [Jagannathan, Kubota, Takehara, 1998] the importance of human capital is confirmed for the case of Japan. As in the previous paper the authors follow [Fama, Schwert, 1977] approach to return on human capital, taking growth rate in per capita labor income in economy as a proxy. The theoretical difference of this paper from [Jagannathan, Wang, 1996] is that it compares the results obtained from estimating the model with human capital to the ones obtained from [Fama, French, 1992] three-factor model, instead of traditional CAPM.

Let us review now some important technical details from [Fama, Schwert, 1977], which will be used further for Russia. An obvious way to test whether the Mayers model improves the pricing of marketable assets is to estimate the differences $\beta_j^* - \beta_j$ between the Mayers and CAPM risk measures of marketable assets.

One of the main contributions of [Fama, Schwert, 1977] is the restatement of Mayers' risk measure. To estimate the betas it is necessary to consider appropriate time series. So, instead of D_H the authors introduce H_t as the aggregate income received at the time t by the labor force employed from $t-1$. They use income per capita of the labor force to measure the variation through time in the payoff to a unit of human capital. The measure of the labor force, L_t, is the seasonally adjusted total civilian labor force collected by the Bureau of the Census of the Department of Commerce. To estimate covariance between income and returns from time series data, one assumes that the bivariate distributions of the income and return variables are stationary through time, which implies that the marginal distributions of the variables are stationary. However, the distribution of per capita income is not stationary — income has an upward trend, and the autocorrelations of per capita income are close to one for many lags. The standard cure for this type of mean nonstationarity suggested by Fama and Schwert is to work with a differenced form of the variable:

$$h_t = \frac{H_t\left(\frac{L_{t-1}}{L_t}\right)}{H_{t-1}} - 1.$$

In new notation Mayers' equation (1) can be rewritten as follows

$$\beta_j^* = \beta_j \frac{\left[1 + \frac{\operatorname{cov}(R_{jt}, H_t)}{V_{m,\,t-1}\operatorname{cov}(R_{jt}, R_{mt})}\right]}{\left[1 + \frac{\operatorname{cov}(R_{mt}, H_t)}{V_{m,\,t-1}\sigma^2(R_{mt})}\right]}. \tag{3}$$

To work with the percentage change in per capita income h_t, the parameters R_{mt} and $\operatorname{cov}(R_{mt}, H_t)$ in (3) must be restated in terms of h_t. Obviously, $H_t = H_{t-1}(1+h_t)$. So (3) can be rewritten as

$$\beta_j^* = \beta_j \frac{\left[1 + \frac{\left(\frac{H_{t-1}}{V_{m,t-1}}\right)\operatorname{cov}(R_{jt}, h_t)}{\operatorname{cov}(R_{jt}, R_{mt})}\right]}{\left[1 + \frac{\left(\frac{H_{t-1}}{V_{m,t-1}}\right)\operatorname{cov}(R_{mt}, h_t)}{\sigma^2(R_{mt})}\right]}. \tag{4}$$

The ratio $H_{t-1}/V_{m,t-1}$ in (4) is estimated as the average of the monthly values of this ratio for the indicated period. Covariances may be calculated directly using standard formulas or on the base of time series estimation (the latter was done in [Fama, Schwert, 1977]). Anyway, we wish to clarify formula (4) where t is present at the right side. In the case of direct calculation t is running across the entire sample (from $t=2$ up to final value of t). In the case of time series the estimates are used.

Here the key point lies in stationarity through time of parameters (variances and covariances) of distributions of R_{jt}, R_{mt} and h_t that appear in usual definition of beta and in formula (3) for the Mayers beta. It gives a possibility to estimate both betas from time series.

So, using the techniques described above Fama and Schwert estimate $\beta_j^* - \beta_j$ for portfolios of New York Stock Exchange (NYSE) common stocks and for portfolios of U.S. Treasury Bills and bonds. Their study covers the 1953–1972 period and both monthly and annual estimates are provided. They find that the differences between the Mayers and CAPM risk measures are very small. The authors attribute this finding to the fact that the relationships between the payoff to human capital and the returns on bonds and stocks are weak, so that any existence of nonmarketable human capital does not have substantial effects on risk for these two important classes of marketable assets. As we already know the last conclusion was corrected in [Jagannathan, Wang, 1996].

2. CAPM WITH NONMARKETABLE ASSETS IN RUSSIA: EFFECT OF SIZE IMPACT

In accordance to the World Bank data for 2017 (see World Development Indicators, 2017) US stock market capitalization is \$32.121 trln whereas Russian stock market capitalization is \$623.425 bln. Access of Russian investors to US market was always not easy. In the period after the world financial crisis, 2010–2017 two circumstances were important for them: (1) unpredictable declines of national currency (RUB), which made very difficult to form rational expectations about stock prices and returns; (2) international sanctions and counter-sanctions appeared since 2014. It became possible to treat US stock market as the market of nonmarketable assets for Russian investors.

Formally, index m stands for Russian stock market represented by (USD denominated) RTSI index and its return, H stands for US stock market represented by S&P500 index and its return. We show that in the case of Gazprom, one of leading Russian companies, traditional CAPM beta is significantly different from the Mayers beta (see Table 1). We use USD-denominated Gazprom ADR prices, which exactly follow Russian RUB prices converted into USD in accordance to official exchange rate. Data are collected from Bloomberg. As it was already said we can assume that ratio of the size of Russian market to US market is zero. So, we can use formula (2) to calculate the Mayers beta.

There is no unique prescription what should be the length of the period to calculate beta. Also different financial agencies use their proprietor algorithms to adjust betas for their practical needs. We start our study from 2010 when the major period of the world financial crisis has ended almost everywhere. All estimates are based on monthly data. The Mayers beta is calculated directly on the base of sample covariations. We treat it as a usual number without taking into account its statistical nature because if too many assumptions being involved. For traditional beta we calculated regressions for 2017 using the data from periods shown.

Now let us move to interpretation of Table 1. One year with monthly estimates is too short period. So the beta of CAPM regression for 2017 is only 5% significant whereas others are 1% significant. The estimate is so poor that though the difference between betas is huge it is not significant

Table 1

Difference between betas: Gazprom case

Periods	Covariance between returns on RTSI and S&P500 index, cov(R_m, R_H)	Covariance between Gazprom and S&P500 index returns, cov(R_j, R_H)	Gazprom, β_j^*	Gazprom, β_j	Significance of difference between betas, level
2017	–0.00174	–0.00271	1.556315	0.92	No
2016–2017	0.002997	0.002585	0.862416	1.32	5%
2015–2017	0.010875	0.009367	0.861350	1.19	1%
2014–2017	0.010337	0.008248	0.797888	1.14	1%
2013–2017	0.009550	0.008916	0.933674	1.14	5%
2012–2017	0.012492	0.012491	0.999939	1.20	10%
2011–2017	0.017058	0.018619	1.091478	1.12	No
2010–2017	0.019939	0.021601	1.083388	1.12	10%

Source: authors' calculation.

even at 10% level. Another case of failure is calculation for the 2011–2017 period. In all other cases the Mayers beta is significantly less than traditional one. In two cases we have even 1% significance level. This methodology can be used for any Russian company.

The Mayers beta is the measure of risk in its traditional sense. So, we have improvement for the risk estimation. In this case the Mayers beta, not traditional one, should be used for investment projects appraisal and WACC.

3. CAPM WITH NONMARKETABLE ASSETS IN RUSSIA: HUMAN CAPITAL CASE

3.1. Research design and data

Since the history of Russian market is very short it is not possible to use advanced time series econometrics mentioned in subsection 1.2 (and described in detail in [Fama, Schwert, 1977, p. 99–102] to see stationarity in reality. Nevertheless, we use the same methodology of proxy and formula (4). The last formula already assumes stationarity. We obtaining CAPM beta from cross section at the monthly basis and then calculate the Mayers beta from (4). This is done for each observation (monthly). Then we apply the paired difference test to decide about the size of $\beta_j^* - \beta_j$.

We consider the 2009–2015 period and monthly data both for human capital and stock market. So we have 84 observations and 83 pairs of betas (notice that $(t-1)$ and t are present in (3)).

The income per capita of the labor force, henceforth called income, is defined as the average wage and salary disbursements to the unit of labor force in the economy as computed by the Federal State Statistics Service of the Russian Federation (https://fedstat.ru).

MICEX value-weighted index (of 50 most liquid stocks of Russia's largest public companies) is considered as a proxy for the market portfolio, and the aggregate capitalization of all securities traded on Moscow Exchange also comprise the total value of marketable assets in the economy. Portfolios of subsets of MICEX stocks provide the different classes of marketable assets for comparing estimates of β_j and β_j^*. Data on the end-of-month total market capitalization of MICEX stocks and values for MICEX index were obtained from "Investfunds" database (http://investfunds.ru).

Estimates for both betas are eventually compared for companies of ten major sectors of economy, i. e. Oil & Gas, Finance, Telecommunications, Energy, Consumer Goods, Transportation, Chemicals, Metal & Mining, Automotive, and Innovations. These sectors and representing companies have been chosen on the base of Moscow Exchange classification (see Appendix and additional information on the site https://www.moex.com/en/index/MICEXO%26G/constituents). It should be noticed that the sector lists refer to January 2016 information.

To calculate the returns on securities a return index (*RI*) is used. It shows a theoretical growth in value of a share for a defined period of time. Dividends are assumed to be reinvested for the purpose of purchasing additional shares at a closing price applicable on the ex-dividend date.

Return index is calculated using the measure called annualized dividend yield. This method adds an increment of 1/260th part of the dividend yield to the price each weekday. Ignoring market holidays, it is assumed that there are 260 weekdays in a year. The base date value of *RI* is 100, and is further adjusted in subsequent time periods using the formula:

$$RI_t = RI_{t-1} \cdot \frac{PI_t}{PI_{t-1}} \cdot \left(1 + \frac{DY_t}{100} \cdot \frac{1}{N}\right),$$

where RI_t — return index on day t; RI_{t-1} — return index on previous day; PI_t — price index on day t; PI_{t-1} — price index on previous day; DY_t — dividend yield % on day t; N — number of working days in the year (taken to be 260).

The calculation ignores reinvestment charges as well as any taxes. Gross dividends are used for calculations where available. Closing prices for the respective periods are used to calculate return index. Returns are calculated based on return index, using the traditional formula:

$$R_{jt} = \frac{RI_{jt}}{RI_{j,t-1}} - 1.$$

As in [Fama, Schwert, 1977] we measure human capital and market in real rather than nominal terms. All of the results below are reported for real versions of the variables, where the real variables are the nominal variables (in RUB) deflated by the Consumer Price Index (CPI).

3.2. Summary statistics

Table 2 presents economy-wide parameters for the sample of Russian companies included in MICEX index. This list of parameters contains market return, market capitalization, total payoff to human capital in the economy, count of labor force and wage per capita.

Market returns at the end of each month in the observed period were calculated as follows:

$$R_{mt} = \frac{MICEX_t - MICEX_{t-1}}{MICEX_{t-1}},$$

where $MICEX_t$ and $MICEX_{t-1}$ are the values of *MICEX* index at t and $(t - 1)$ respectively, t is the last trading day of the month between in the 2009–2015 period. So our study includes 84 months.

The mean value for market returns is 0.015, and median 0.018 (1.5% and 1.8%), while standard deviation is more than 4 times higher than the mean (6.5%). The same can be observed for h_t, with the same mean of 0.015, it has standard deviation of more than 7 times higher than the mean (11.9%).

As for other variables, the level of volatility is lower and standard deviations are much less than one mean. Market capitalization has the mean and median of around RUB 25 trillion, with a standard deviation of only RUB 4.26 trillion. Total payoff to human capital has the mean and median of RUB 1.9 trillion, with a standard deviation of 0.45 trillion. It is worth to mention that the lowest relative standard deviation is that of a labor force. With

Table 2

Summary statistics for market data and wages

Parameters	Mean	Standard error	Median	Standard deviation	Interval	Minimum	Maximum
R_m	0.015	0.007	0.018	0.065	0.356	–0.135	0.221
Market cap, mln	24 936 094	464 777	25 195 296	4 259 753	21 269 847	10 643 790	31 913 636
Wage per capita	26 761	666	26 652	6101	26 310	17 098	43 408
h_t	0.015	0.013	0.011	0.119	0.627	–0.276	0.350
Labor force	70 844 062	79 358	71 229 715	727 324	2 134 958	69 410 458	71 545 416
Total payoff to H, mln	1 899 321	48 838	1 902 658	447 604	1 890 958	1 209 472	3 100 430

Source: http://investfunds.ru, https://fedstat.ru, authors' calculations.

the sample mean and median of 71 million, it has standard deviation of only 0.73 million.

3.3. Empirical analysis and results

Our goal is to test whether the differences $\beta_j^* - \beta_j$ are significantly different from zero. We will use the test of the mean difference of two populations based on dependent samples, or 'paired difference' test, assuming normal distributions [Wooldridge, 2016, Appendix C] (there are no extreme outliers so we can conclude that distributions are approximately normal).

Formula (4) is valid for any portfolio, so we can estimate both betas indices for all 10 sectors. We have 83 observations in each case. Let μ_d is the mean of the population of paired differences $\beta_j^* - \beta_j$ for companies included in the sample.

We specify the null and alternative hypotheses (two-tailed test) as

$$H_o : \mu_d = 0;\ H_a : \mu_d \neq 0.$$

If null hypothesis is accepted then human capital is not important for this sample. If null hypothesis is rejected then human capital is important for this sample. Let $\bar{d}$ be the mean and s_d be the standard deviation of sample difference; $s_{\bar{d}} = s_d / \sqrt{n}$ is the standard error of the mean difference. If n is the number of paired observations then $(n-1)$ is equal to degrees of freedom and t-statistics is defined by the formula

$$t_{n-1} = \frac{\bar{d}}{s_{\bar{d}}}.$$

In our case the value of t-statistic should be compared with critical value (from Student's t-distribution) based on $n-1 = 83-1 = 82$ degrees of freedom and 5% level of significance. In this case critical value is equal 1.99. So, for the null hypothesis to be rejected the t-test should be greater than t-critical in absolute value, i.e. the following inequality must hold: $|t_{n-1}| > 1.99$.

To estimate the differences $\beta_j^* - \beta_j$ we need to calculate both betas. The estimate of β_j are the slope coefficients from market model regressions of R_{jt} on R_{mt} where m is the value-weighted MICEX index. All beta coefficients are significant at 5% level. The estimates β_j^* of the Mayers risk measure use the market model estimates for β_j and the standard formulas for sample covariances and variances for the remaining parameters in (4). Covariances technically may be also estimated from suitable regressions as it is mentioned in paper [Fama, Schwert, 1977; see formula (8) and table 7].

Table 3

t-statistics for the betas differences (2009–2015)

Sector	$\beta_j^* - \beta_j$, sector	t-statistic
Oil & Gas	0.0048	0.14
Innovation	–0.0620	–2.83
Telecom	–0.0049	–0.17
Energy	0.0034	0.23
Consumer Goods	0.0100	0.09
Transportation	–0.0600	–2.27
Finance	0.0019	0.03
Chemicals	–0.0010	–0.11
Automotive	–0.0062	–0.25
Metals & Mining	–0.0235	0.48

Note: gray cells indicate significance of the betas' difference for the sector.

Source: authors' calculations.

Table 3 shows the t-statistics calculated for each sample of pairs of the beta's differences as it is described earlier. The question posed for Table 3 is whether there are important differences between the Mayers and CAPM risk measures for the marketable assets in general. The answer seems to be "no". The difference is very small in absolute value. However, even though one can infer from Table 3 that the values of $\beta_j^* - \beta_j$ are close to zero for MICEX stocks in general, there may be subclasses of stocks for which there are important differences between the two risk measures.

For this reason, the stocks were divided (in according to their MICEX sectors) into 10 major classes of assets (see Appendix), and differences $\beta_j^* - \beta_j$ were calculated for each group, which has yielded some positive results. Yet, although for most classes the differences between the Mayers and CAPM betas are close to zero and statistically insignificant, for Innovation and Transportation sectors the differences are as large as 8.5% and 9.2%.

3.4. Interpretation of the results and limitations

Due to the nature of Russian economy, which is infrastructure-intensive and resource oriented, human capital plays in general a less significant role, than in more developed and innovation-oriented countries. Therefore, it is not surprising that the effect from inclusion of human capital is negligible for the market in general and for the most sectors. As for Innovation sector, the results that were obtained are meaningful, since this type of corporations usually is very dependent on personnel. Human capital plays a key role as a driver for innovations. The founders of the theory of human capital, H. Becker and T. Schultz, proved productive nature of the investments in people, providing a significant and lasting effect. For example, [Schultz, 1960] identified the formation of human capital with investments in education.

There are some doubts interpreting the results for Transportation sector. Generally speaking this sector is related to high end technologies and innovations but, given a more detailed look at the companies, comprising the sector, one can see that they are neither numerous nor representative of the sector, and operate in different segments of transportation.

Now we add some comments on limitations of the study. First of all information on salaries and wages in Russia is incomplete. Second, one can argue that the companies comprising sectors in this paper are not representative of the sector or scarce to make general conclusions. We consider this point quite valid. However, the following points must be taken into account:

- The decision on assigning the stocks to certain sectors was based on the methodology of MICEX/Moscow Exchange for choosing companies for sector indices.
- The most comprehensive data on the Russian stock market was used.
- With the current state of market itself and market data, it is difficult to collect better data.

CONCLUSION

In this paper we presented two attempts to test CAPM with nonmarketable assets. In the case of analysis of the small size effect in the Russian stock market we have shown the possibility of substantial improvement of risk exposure estimate. Let us continue the discussion of this case. We provided the general methodology explaining it for the Gazprom case. Of course, a more detailed study for all liquid stocks is welcome. Since CAPM, despite of its critics in the case of asset pricing, is still recommended for WACC calculation [Berk, Binsbergen, 2017] then the use of the Mayers beta may occur perspective.

There is a huge stream of literature devoted to comparison between the global CAPM (GCAPM), where the only risk factor is the global market index, and the international CAPM (ICAPM) with two risk factors, the global market index and a wealth-weighted foreign currency index (the most recent reference for 46 countries including Russia is [Ejara et al., 2018], added in proof). Obviously this approach is relevant for the topic but it will never explain how Gazprom, with top three capitalization in 2006 and which still is the world's largest energy major in terms of natural gas reserves and production (as of 2017), became a troubled company in 2018 with Price-to-Sales ratio of about 0.2.

In [Teoh, Welch, Wazzan, 1999] authors show with rigorous econometric analysis that in the case of South Africa under sanctions the following claim is true: both US companies made business in this country and South African financial markets themselves have not been visibly affected.

This means that our model captures some elements of reality. Of course further development is needed.

Empirical analysis in the case of human capital has shown significant difference of the estimates of two models for Innovation sectors. The beta predicted by the Mayers model is 9.2% higher than the CAPM beta. The research has failed to find any impact of the model for other sectors of the market. Taking into account negative experience of [Fama, Schwert, 1977] we conclude that the original Mayers model for human capital is not suitable for studying influence of human capital on market risk.

The most recent paper [Berk, Walden, 2013] on human capital risk moves the focus from companies to employees. The paper is technically based on analysis of stochastic processes. It analyses the issue of "limited capital market participation", which can be relevant to our idea of duality of companies' assets valuation.

Appendix

LIST OF STUDIED COMPANIES BY SECTOR

Sector	Company
1	2
Oil & Gas	Gazprom, Rosneft, Lukoil, NOVATEK, Transneft, Tatneft, Surgutneftegaz, Bashneft, Slavneft-Megionneftegaz
Energy	FSK EES, Interrao, Polus Gold, MMK, Eon Russia, Rus Hydro, Rosseti, Mosenergo, OGK-2, Irkutskenergo, T Plus Group, Enel Russia, MOESK, TGK-1, MRSK-1, TNS Energo, MRSK CP, VTORRESURSY, Nauka-Svyaz, MRSK Ural, MRSK Volgi, DVEC, Quadra, MRSK Yuga, MRSK Sevzap, Lenenergo

Appendix (continued)

1	2
Metals & Mining	Severstal, ALROSA, GMK Norilsk Nikel, NLMK, Polymetal International, PhosAgro, Uralkali, RUSAL, VSMPO, TMK, Mechel, Zinc, Raspadskaya, Kuzbasskaya Toplivnaya Co, LenZoloto, Chelyabinsky Metallurgicheskiy Kombinat, Amet
Innovation	Qiwi, Human Stem Cells Institute, Pharmsynthez, United Aircraft Corporation, Donskoi Zavod Radiodetalei, Multisistema, Diod, CZPSN-Profnastil, Rollman Group, Levenhuk
Consumer Goods	M.video, Lenta, Magnit, Dixy Group, RosAgro, Cherkizovo Group, Pharmstandard, Protek, Otcpharm, Razgulyai Group, Russaquaculture
Telecom	MTS, Rostelecom, Megafon, MGTS, Central Telegraph
Chemicals	Acron, Nizhnekamskneftekhim, Kazanorgsintez
Transportation	Aeroflot, Novorossiysk Commercial Sea Port, Fesco, Utair
Finance	Moscow Exchange, Sberbank of Russia, VTB, AFK Sistema, Bank Saint Petersburg, Vozrozhdenie Bank
Automotive	Uniwagon, Sollers, AutoVaz, GAZ

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Модель CAPM с не торгуемыми активами на российском фондовом рынке

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В работе рассматривается модификация модели CAPM, носящая имя «модель Майерса», которая учитывает существование не торгуемых активов. Человеческий капитал является классическим примером таких активов, хотя мы приводим и рассматриваем некоторые другие важные интерпретации. В данной работе предприняты две попытки тестирования полезности CAPM с не торгуемым активом. Мы начали с анализа влияния эффекта малого размера российского фондового рынка. Оказалось, что модель Майерса позволяет значимо уточнить модель оценки риска. Далее, эмпирический анализ показал, что в случае человеческого капитала модель Майерса не дает никакой существенной информации ни для одного из секторов Московской фондовой биржи за исключением сектора инноваций.

Ключевые слова: не торгуемые активы, CAPM, модель Майерса, российский фондовый рынок, человеческий капитал.

JEL: G11, G12, G32, J24.

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